

WHAT IS CLAIMED IS

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1. A time-varying multi-path generating apparatus for simulating multi-path fluctuations in radio communications, comprising:  
a parameter control unit for controlling a  
10 plurality of conditions for generating a plurality of propagation paths, the conditions being parameters and data files,  
a data storage unit for storing the parameters and data files for generating the  
15 propagation paths,  
a random number generating unit for generating and outputting a plurality of random numbers based on a random number parameter provided by the parameter control unit, and  
20 a propagation path generating unit for generating a plurality of time-varying propagation paths, wherein  
a plurality of time-varying amplitude functions and a plurality of time-varying phase  
25 functions are generated based on the parameters and data files for propagation path generation stored in the data storage unit, and the random numbers generated by the random number generating unit,  
the time-varying amplitude functions are  
30 aligned serially in the time domain such that a time-varying shadow amplitude function is obtained, which is repeated N times, where N represents the number of the propagation paths, resulting in N time-varying shadow amplitude functions,  
35 the time-varying phase functions are aligned serially in the time domain such that a time-varying shadow phase function is obtained,

which is repeated N times, where N represents the number of the propagation paths, resulting in N time-varying shadow phase functions,

an initial amplitude, an initial phase, an  
5 initial time delay, and an initial arrival direction  
are generated as the propagation path parameters of  
a propagation path using random numbers provided by  
the random number generating unit based on the  
initial value generation parameters stored in the  
10 data storage unit, and  
the time-varying shadow amplitude  
functions and the time-varying shadow phase  
functions are superimposed on the initial amplitude  
and the initial phase, respectively, for generating  
15 a plurality of time-varying propagation paths.

20 2. A time-varying multi-path generating  
apparatus for simulating multi-path fluctuations in  
radio communications, comprising:

a parameter control unit for controlling a  
plurality of conditions for generating a plurality  
25 of propagation paths, the conditions being  
parameters and data files,

a data storage unit for storing the  
parameters and data files for generating the  
propagation paths,

30 a random number generating unit for  
generating and outputting a plurality of random  
numbers based on a random number parameter provided  
by the parameter control unit,

a time-varying function generating unit  
35 for generating and outputting a plurality of time-  
varying amplitude functions and time-varying phase  
functions, serving as shadow characteristics of the

propagation paths based on a shadow parameter stored  
in the data storage unit and the random numbers  
provided by the random number generating unit, and  
a propagation path generating unit for  
5 generating a plurality of time-varying propagation  
paths, wherein  
the time-varying amplitude functions and  
the time-varying phase functions generated and  
provided by the time-varying function generating  
10 unit are aligned serially in the time domain such  
that a time-varying shadow amplitude function and a  
time-varying shadow phase function, respectively,  
are obtained, which obtaining is repeated N times,  
where N represents the number of the propagation  
15 paths, resulting in N time-varying shadow amplitude  
functions and N time-varying shadow phase functions,  
respectively,  
an initial amplitude, an initial phase, an  
initial time delay, and an initial arrival direction  
20 are generated as the propagation path parameters of  
a propagation path using the random numbers provided  
by the random number generating unit based on  
initial value generation parameters stored in the  
data storage unit, and  
25 the time-varying shadow amplitude function  
and the time-varying shadow phase function are  
superimposed on the initial amplitude and the  
initial phase, respectively, for generating a  
plurality of time-varying propagation paths.  
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3. The time-varying multi-path generating  
35 apparatus as claimed in claim 1, wherein the  
propagation path generating unit generates the time-  
varying amplitude functions and the time-varying

phase functions using the random numbers generated by the random number generating unit; the random numbers have correlations corresponding to inter-parameter correlation characteristics related to an arriving propagation path angle difference that is stored in the data storage unit for each of the propagation paths; and a shadow time interval, a shadow amplitude, and a shadow occurrence time interval are generated as correlated random numbers that are used as constant parameters of a time-varying function.

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4. The time-varying multi-path generating apparatus as claimed in claim 1, wherein the propagation path generating unit adds a time-varying phase rotation to the time-varying phase characteristic of each time-varying propagation path by calculating the time-varying rotation due to the Doppler effect based on a moving speed of a mobile station, the moving speed being provided by the parameter control unit, and the initial arriving direction of each propagation path.

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5. The time-varying multi-path generating apparatus as claimed in claim 1, wherein:  
the data storage unit stores directional-gain pattern files of a plurality of antennas applicable to a mobile station, the directional-gain pattern files being provided by the parameter control unit, and containing information about directional gain, and

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the propagation path generating unit reads at least one of the directional-gain pattern files according to moving directions of the mobile station, calculates N propagation paths by multiplying the directional gain to the initial amplitude of each propagation path to obtain N time-varying propagation paths, which is repeated M times, M being the number of the antennas, and NxM time-varying propagations propagation paths are generated.

6. A multi-path fading simulator, comprising:  
the time-varying multi-path generating apparatus for generating N propagation paths for each of M antennas,  
a propagation path output unit for dividing MxN complex amplitudes of the time-varying propagation paths provided by the time-varying multi-path generating apparatus into real parts and imaginary parts, and outputting the real parts and the imaginary parts in an analog form, and  
a signal synthesizing unit, comprising:  
at least one digital signal input terminal,  
at least one digital signal output terminal,  
an orthogonal signal generating unit for generating a plurality of orthogonal input signals (Q component) based on a plurality of digital signals (I component) input through the digital signal input terminal,  
2xM transversal circuits, each comprising (N-1) delay elements that are cascaded, and N multipliers, wherein  
each of the I component and the Q

component is distributed to specific transversal circuits,

each of the N multipliers is provided with the respective real part, or the respective  
5 imaginary part, as applicable, output by the propagation path output unit, the real part or the imaginary part, as applicable, having an initial time delay, and the time delay of each multiplier is set equal to the time delay of the real part or the  
10 imaginary part, as applicable, and

each digital signal delayed by 0, one or more delay elements, as applicable, and the propagation path fluctuation that is represented by the real part or the imaginary part, as applicable,  
15 are multiplied, and

M signal synthesizing units for adding the multiplication results of every delay time such that the I component and the Q component are obtained, for combining the I component and the Q component  
20 such that a digital signal is generated for each of M antennas, and for outputting the digital signal to the digital signal output terminal.

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7. A time-varying multi-path generating method for simulating multi-path fluctuations in radio communications, comprising:

30 a step wherein a plurality of propagation path generation parameters and data files of propagation paths to be generated are stored in a data storage unit, the data files comprising propagation path generation parameter files, antenna  
35 directional gain pattern files, and time-varying function constant parameter generation condition files,

a step wherein the parameter control unit reads the propagation path generation parameter files from the data storage unit

5 a step wherein the parameter control unit reads data files about M antennas, such as the antenna directional gain pattern files, from the data storage unit,

10 a step wherein the random number generating unit generates random numbers that fulfill propagation path parameter initial value generation conditions of a propagation path to be generated,

15 a step wherein the propagation path generating unit sets up initial conditions, such as initial amplitude values of N propagation path parameters based on the random numbers,

20 a step wherein the N initial amplitude values and antenna directional gains to a direction of an incoming propagation path obtained from the antenna directional gain pattern file are multiplied to obtain  $N \times M$  propagation path parameters, which parameters are set up,

25 a step wherein the parameter control unit reads the time-varying function constant parameter generation condition files from the data storage unit,

30 a step wherein the propagation path generating unit generates time-varying function constant parameters based on random numbers generated by the random number generating unit,

35 a step wherein the propagation path generating unit generates time-varying shadow amplitude characteristics and time-varying shadow phase characteristics of N propagation paths based on the time-varying function constant parameters, and generates shadow fluctuation characteristics of the amplitude and the phase of each of the N

propagation paths, and

a step wherein time-varying multi-paths are generated based on the generated shadow fluctuation characteristics.

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8. A time-varying multi-path generating method for simulating multi-path fluctuations in radio communications, comprising:

a step wherein a plurality of propagation path generation parameters and data files of propagation paths to be generated are stored in a data storage unit, the data files comprising propagation path generation parameter files, antenna directional gain pattern files, and time-varying function constant parameter generation condition files,

a step wherein the parameter control unit reads the propagation path generation parameter files from the data storage unit,

a step wherein the parameter control unit reads data files about M antennas, such as the antenna directional gain pattern files, from the data storage unit,

a step wherein the random number generating unit generates random numbers that fulfill propagation path parameter initial value generation conditions of a propagation path to be generated,

a step wherein a propagation path generating unit sets up initial conditions, such as initial amplitude values of N propagation path parameters based on the random numbers,

a step wherein the N initial amplitude values and antenna directional gains corresponding



to a direction of an incoming propagation path  
obtained from the antenna directional gain pattern  
file are multiplied to obtain NxM propagation path  
parameters, which parameters are set up,  
5           a step wherein the parameter control unit  
specifies a calculation model based on the  
propagation path generation parameter files,  
          a step wherein the random number  
generating unit generates random numbers  
10           corresponding to shadow parameters,  
          a step wherein the time-varying function  
generating unit generates N time-varying functions  
for the specified calculation model based on the  
random numbers, and  
15           a step wherein, time-varying shadow  
amplitude characteristics and time-varying shadow  
phase characteristics are generated for N  
propagation paths based on the generated time-  
varying functions generated by the propagation path  
20           generating unit, which amplitude characteristics and  
phase characteristics are multiplied by the  
amplitude and the phase, respectively, of each  
propagation path such that shadow fluctuation  
characteristics are generated, and  
25           a step wherein time-varying multi-paths  
are generated based on the generated shadow  
fluctuation characteristics.